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SMALL TURBINE COLUMN:

Residential Wind Turbines and Lightning

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Questions frequently arise at zoning hearings about residential wind generator towers and lightning strikes. While this question is often couched merely as a query, occasionally a wind opponent will attempt to use lightning as a scare tactic in an attempt to get the zoning authority to deny a building permit for the wind system. I have heard some opponents even claim that the tower will actually attract lightning strikes to the area.

Unfortunately, some of this information has even trickled down to insurance companies, a few of which have become hesitant about insuring residential wind systems. This is not because an inordinate number of turbine owners have made lightning damage claims, but because the insurers—who tend to have little experience with or knowledge of small wind systems—believe it is plausible that such an event might happen.

The reality is that a properly installed residential wind system is no more attractive to lightning than any other metal object on the landscape. Indeed, when one examines the statistical incidence of lightning strikes on wind generator towers as a fraction of the population of towers versus the statistical incidence of trees being struck as a percentage of their population, trees are struck far more frequently than towers are. This seems counterintuitive, since we all know that metal conducts electricity, right?

Understanding what is going on with lightning and towers is really quite simple.

Imagine yourself on a cold winter Sunday morning, a toasty fire glowing in the woodstove, shuffling your feet on the carpet as you trudge towards your favorite chair with coffee cup in hand and newspaper under arm. There, curled up just where you want to relax, is that cat again. You stick your finger out near the cat's nose and zapp!, the cat instantly disappears, and you have your chair back for the next few weeks. What just happened?

We've all experienced this scenario, but maybe not exactly as depicted above. If you don't have a house cat, you may have been startled by a flash of static electricity while reaching out to a doorknob. What is going on here?

Remember back to elementary school science class, when you dutifully performed various simple experiments. Rubbing a piece of amber over rabbit fur would result in a similar static buildup and discharge. What you "discovered" was static electricity. Given the right conditions, rubbing two dissimilar materials over each other causes static electricity buildup. That static charge needs to reach equilibrium somehow. In the case of you and your cat, the static builds up on you as you shuffle across the carpet. When you, insolated from the carpet by socks or slippers, extend your finger to the cat's nose, or a doorknob, this static has its chance to reach equilibrium.

Exactly the same thing is happening with lightning, only on a much grander scale. The two dissimilar materials are the atmosphere and the earth. As air masses roll over the surface of the earth, a static charge builds up between the earth and atmosphere that surrounds our globe, essentially creating a giant capacitor storing this static charge. At some point the static electricity has to equalize. It does so between 2,000 and 3,000 times a minute somewhere on Earth, and this is what we call lightning. Quite impressive relative to our hand touching a doorknob! But then, the Earth is quite a capacitor.

It turns out that lightning is not necessarily attracted to tall metal objects. Understanding how to protect a wind system from lightning strikes essentially means applying our elementary school science lesson to a real-world situation. If you bleed off the static charge, there will be no spark. With a wind turbine, you can bleed off the static charge by getting the static electricity to the earth, potentially with ground rods.

We have known how to protect structures from lightning for quite some time. For example, I live in an area where many of the buildings have metal roofs to shed the considerable snow buildup in the winter. The metal roofs were installed during the 1930s and 1940s in this area. We have three buildings with such roofs--our house, barn, and an old log cabin. Each of these metal roofs has a heavy wire extending from each corner of the roof down to the ground, where the wire is buried. The purpose of these wires is to bleed off the static charge that builds up on the roofs, thereby making the roof less attractive to lightning strikes.

The way this is done with residential wind towers is to install a ground rod at each point where the tower foundation comes in contact with the earth. For a three-legged free-standing tower, this will mean three ground rods, one for each leg. For a guyed tower, it means four ground rods; one for the tower itself, and one for each of the three guy anchors. (For a guyed tilt-up tower, it will mean five ground rods; one for the tower and one for each of the four anchors.)

As mentioned above, trees are struck far more often than towers, on a percentage of the population basis. The reason for this is because towers can be grounded to bleed off the static charge. And while trees are growing in the ground, they are poor conductors and cannot easily rid themselves of their built-up static electricity. Indeed, there is a thriving business in some southern states where entrepreneurs will ground hundred-plus year oak trees (oaks have a high resistance and are particularly poor conductors of electricity) that were planted by someone's great grandparents. This involves winding copper wires around the oak tree's branches, then terminating these wires at ground rods driven into the Earth. This system effectively bleeds off the tree's static electricity, making them less attractive to lightning.

Grounding a structure's static charge does indeed work to minimize lightning strikes, to an extent. Like any uncontrollable force in Nature, however, it is no guarantee that lightning will not strike a tower. To that end, back up technologies are installed on wind towers. These include lightning arrestors and surge arrestors.

Lightning arrestors, known in the trade as "silicone oxide varistors" or "SOVs," are essentially spark gap arrestors. Inside the SOV is something that looks like a spark plug, surrounded by white sand. One end of the "spark plug" is attached to the wind turbine's wiring, while the other end is connected to the ground rod at the base of the tower. The sand is actually a dielectric material that will conduct electricity when a certain voltage is reached. In theory, if lightning strikes your tower and lightning travels down the wiring towards the battery bank or inverter in your house, the SOV's job is to safely shunt that lightning strike to ground. I say "in theory" because, like ground rods, there is no guarantee that they will work every time. Sometimes lightning doesn't follow our rules but instead goes where it wants to.

SOVs should be installed on the incoming tower wiring as well as the utility wiring for grid-tied systems. In reality, lightning strikes are orders of magnitude more frequent on the utility grid than strikes on properly grounded towers. The reason is that the utility "grid" is indeed a grid network of current-carrying conductors that blanket the countryside, as opposed to your single tower structure.

Yet another potential lightning problem is caused, not by a direct lightning strike, but by a nearby strike. When lightning strikes the ground near your home, it may set up a current in either the atmosphere or the earth. This current sets up a bull's eye voltage wave pattern that looks quite similar to a quiet pond after you have dropped a pebble into it. As the waves move away from the strike area, they diminish in magnitude. If, however, one of these waves crosses something that is capable of carrying a current, your tower or buried wires for example, a current will be induced in that object.

A familiar example of this phenomenon is the random ringing that occurs on a land-line telephone during a lightning storm. As lightning strikes the ground, waves are set up in the ground that travel away from the strike point. If one of these waves crosses a buried telephone line, a current is induced in that phone line. That current travels down the phone wires until it reached your telephone ringer, and the bell dings.

Similar currents can be set up in wind turbine and tower wiring due to nearby lightning strikes. The mode of protection for this problem is to install devices known as metal oxide varistors, or MOVs, on the tower wiring. MOVs are used in computer surge arrestors to offer the very same protection to the sensitive electronics in our homes from surges that often occur on utility or telephone lines.

So, wind turbine towers do not attract lightning, but can be struck just like any other unprotected metal object. Protection includes the installation of ground rods on the tower and anchors and the addition of both MOVs and SOVs on both the tower wiring and the utility grid wiring.

Will these measures guarantee that you will never be struck by lightning? Probably not. Lightning, which travels miles through the poor conductor we call the atmosphere, will pretty much do as it pleases. Ground rods, SOVs, and MOVs, however, are the best devices that we have available to us today to minimize our exposure to lightning strikes based on our present understanding of how lightning works. And as an insurance adjustor once told me, by adding these devices to your system you have installed all of the precautionary devices offered by our best understanding of the science of lightning. You have done all that a prudent homeowner can do.

[Editor's Note: The opinions expressed in this column belong solely to the author.]